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ABSTRACT

A study of the effects of the Instrumental Enrichment cognitive intervention program with 41 severely hearing impaired secondary school students was conducted. Experimental and control groups were compared in regard to general cognitive functioning, problem-solving strategies, reading comprehension, and mathematics. Experimental subjects were provided systematic (at least twice a week) mediated learning experiences intended to help students understand their own thinking processes and promote generalization to both curricular and non-school situations. The specially trained teacher incorporated a series of sequenced visual, verbal, and geometric problems into the regular subject matter, helped students solve the problems, and then discussed how the students' mental strategies on these problems would be used in the subject matter. Experimental subjects demonstrated improvement in (1) systematic approaches to problems, (2) analysis of problem situations, (3) analysis of source-of-error in problem-solving situations, (4) completeness, organization, and planning in problem solving situations, (5) peer cooperation in problem solving, (6) abstract thinking, and (7) a variety of cognitive based classroom behavior. Results supported the value of systematic rather than incidental cognitive intervention. (Author/DB)

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COGNITIVE MODIFIABILITY IN THE DEAF ADOLESCENT

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Abstract

A study of the effects of the cognitive intervention program Instrumental Enrichment for hearing-impaired adolescents was conducted. Experimental and control groups were contrasted in regard to general cognitive functioning, problem-solving strategies, reading comprehension, and mathematics. Experimental subjects were found to demonstrate improvement in: (a) systematic approaches to problems, (b) analysis of problem situations, (c) analysis of source-of-error in problem-solving situations, (d) completeness, organization, and planning in problem-solving situations, (e) peer cooperation in problem-solving, (f) abstract thinking, and (g) a variety of cognitively-based classroom behaviors. These results establish the efficacy and strong potential of systematic cognitive intervention programs for improvement of thinking skills in the hearing-impaired adolescent.

Introduction

Teachers who work with hearing-impaired adolescents frequently express deep concern and frustration about some of their students' serious deficiencies in problem-solving skills, as evidenced in both classroom and written work. The concern often relates to difficulty in manipulating more than one variable, conceptualizing what a textbook or journal author is saying, forming conclusions, dealing with hypothetical data, and spatial reasoning. Yet research with hearing-impaired adolescents has documented that no basic malfunctions are present in the cognitive abilities of that population and that any inferiorities in cognitive performance may be accounted for by experiential and linguistic deficits and communication handicaps (Levine, 1976).

Literature Background

Studies in cognition in hearing-impaired persons have been numerous in recent years. After an initial period of research focusing on I.Q., the center of attention now is on the processes involved in cognition and perception. It appears to be generally accepted that hearing-impaired persons have the normal range of intelligence when tested on the performance, rather than the verbal, subtests of various I.Q. instruments (Drever & Collins, 1928), with the exception of students who have neurological impairments resulting from an etiology of hearing loss that has multiple effects (Vernon, 1968). In a more detailed examination of hearing-impaired subjects by specific etiology of loss, however, some differentiation in performance is also found; for example, the mean I.Q. for "genetically deaf" students was reported to be 114, while that for post-maternal rubella deaf students was 95 (Vernon, 1968). When the influence of age is controlled, statistical data

indicate strong relationships between achievement test scores and variables such as age of onset of hearing loss, cause of loss, degree of loss, additional handicapping conditions, ethnic background, and type of special educational program (Jensema, 1975).

The relationship between language and cognition is both essential and complex. We know, for example, that using language enables us to restructure mental schemata, perceive reality in new ways, and redesign the strategies employed to solve problems (Klein, 1981). A major body of research during the past 50 years indicates that language in social interaction is critical to effective cognitive development (Vygotsky, 1962, 1978; Wertsch, 1978). The work of Halliday (1973) and Tough (1977) has reinforced Vygotsky's work and given new insights into the degree of linguistic use by children in attacking cognitive problems. It is highly appropriate that an intervention program for hearing-impaired learners in the area of cognitive development recognize and use language in a systematic manner, especially since the linguistic deficits of hearing-impaired learners are considered to be partly responsible for some of their difficulties in cognition.

It is also useful to review what prior researchers have reported in regard to specific cognitive skill performance in hearing-impaired individuals. No difference is found between deaf and hearing learners in certain cognitive tasks, such as: parts-wholes relationships (Furth, 1964), similarity (Furth, 1964; Meadow, 1980), and symmetry (Furth, 1964; Meadow, 1980). However, hearing-impaired children have been found to perform less well than hearing children on other skills, such as: short-term memory (Karchmer & Belmont, 1976), concept application (Meadow, 1980), dissimilarity

(Furth, 1964; Meadow, 1980), analogy (Meadow, 1980), superordinate reasoning (Johnson, 1981), classification (Roberts, 1975), spatial reasoning in terms of field-dependence (Parasnis & Long, 1979), and working with several types of data (Otten, 1980).

If we accept the fact that certain specific cognitive deficiencies do exist for hearing-impaired individuals but that no evidence suggests less than the normal range of intellectual potential among hearing-impaired individuals as a group, then it is apparent that a "cognitive education" program may promise improvement of these skills.

"Cognitive education" is used here to mean those classroom activities in which the teacher explicitly focuses student attention on generic and transferable cognitive skills separate from any particular subject-matter context. Although cognitive skills such as hypothesizing, evaluating, and analyzing, have been embedded in school curricula for many years, that embedding may not be sufficient to make them explicit to the learner. Specifically, some learners seem to carry out hypothesizing, for example, in a science context, but when meeting a puzzling situation in a literary plot, seem not to be able to hypothesize there. As a result, there is need for explicit rather than implicit emphasis. Thus, "cognitive education" includes those activities in which the teacher focuses student attention on such skills in a content-free way and in which the teacher discusses those skills in a metacognitive manner before helping students to see their applications to subject matter.

Instrumental Enrichment (IE) was developed by Feuerstein (1978, 1980) in response to the need for mediated learning experiences for culturally disadvantaged groups. This program uses a "metacognition" approach in that

students are given repeated opportunities to reflect on their own thinking processes. Unlike cognitive training programs focusing on impulsivity as a personality characteristic, Feuerstein's work assumes that impulsivity is a characteristic of the "retarded performer" due to lack of adequate mediated learning experience. Thus, I.E. assumes that impulsivity may be reduced or eliminated, but for a different reason than the other programs. I.E. develops the prerequisites for learning and does not assume that those prerequisites already exist in the learner. I.E. recognizes the age-specificity of developing generalizable cognitive strategies. Feuerstein is unambiguous about the I.E. program's appropriateness only for learners at the representational level of thinking and beyond. I.E. does not assume that generalization will automatically occur; rather, a critical element in the daily instructional sequence for I.E. is the "bridging" exercise in which the teacher overtly and actively promotes transfer by the student of skills to both real-life and curricular situations. This activity occurs during group discussion for insight and requires specific teacher training. Thus, the I.E. program represents a highly logical intervention step in the history of cognitive intervention programs.

The Study

The purpose of the present study was to examine the effects of the I.E. intervention for hearing-impaired students. Six I.E. instruments (parts-wholes, comparison, symmetry, projection of virtual relationships spatial relationships, following directions, and classification) were used over a two-year period with an experimental group of secondary-level hearing-impaired students.

The specially trained teacher at least twice per week incorporates a series of sequenced visual, verbal, and geometric problems into the regular subject matter; helps students solve these problems; then discusses how the students' mental strategies on these problems would be used in the subject matter.

It was hypothesized that hearing-impaired students who have regular opportunities to carry out generic work in the improvement of cognitive skills will demonstrate:

1. Significant improvement in logical thinking as measured in their responses to hypothetical problem-solving situations.
2. Significantly improved achievement in reading comprehension.
3. Significantly improved achievement in mathematics computation.
4. Significantly improved achievement in mathematics concepts.
5. Practicality, completeness, organization, and systematic planning in their responses to hypothetical problem-solving situations.
6. Transfer of systematic problem-solving skills to class work in contexts other than where the cognitive intervention takes place.

Method

Subjects

The two-year pilot project took place at the Model Secondary School for the Deaf (MSSD) at Gallaudet College in Washington, D.C. Performances of a control group of 41 students and an experimental group of 41 students were contrasted using several measures of cognitive functioning. Groups were matched on the basis of age, sex, degree of hearing loss, and reading ability; I.Q. data were not available for the matching process. Hearing loss averaged

88 dB; reading level averaged 4.5 (GLS) on the SAT-HI; and age averaged 16.5 years old.

Instruments and Procedures

Raven's Standard Progressive Matrices assess general intellectual capacity by requiring an individual to solve a series of increasingly difficult abstract design problems. The Raven was selected as particularly appropriate for assessing students' analogical reasoning, systematic planning behavior by comparison of students' level of accuracy with their elapsed time on the test itself, and distinction between relevant and irrelevant cues. This instrument was administered to both experimental and control subjects as a pretest, after one year, and after two years.

The Reading Comprehension subtest of the Stanford Achievement Test Hearing Impaired Version (SAT-HI) Version 6, uses multiple choice responses to written questions to assess an individual's ability to construct a coherent interpretation of an extended prose passage, as well as measuring specific decoding skills such as finding main ideas or locating supporting data. This part of the SAT-HI was selected as a measure of inferential thinking, understanding of implicit meaning, and ability to consider multiple sources of information. The subtests on Math Computation and Math Concepts are generally accepted as measures of these skills for hearing-impaired learners. The Experimental and Control students took the entire SAT-HI test in November 1982 and again in November 1984.

Problem-Solving situations were presented for written responses. The three problems were:

1. Suppose you are responsible for planning a trip for a class to go from MSSD to downtown Washington for a whole day to visit the Capitol building. What steps would you take? Please list the things you would have to plan.

2. If you had to tell someone exactly how to walk from the Auditorium at MSSD to the Cafeteria, what directions would you give him or her?

3. You are in a restaurant downtown with an MSSD friend. After dinner, your friend becomes sick from the food he has eaten. He can't walk, and he is in pain. The restaurant manager refuses to help you. What would you do?

Problem-solving situations were selected as a means of assessing students' planning behavior, problem-identification ability, skill in dividing a problem into its components, and understanding of cause and effect relationships.

Two independent raters were trained to a .85 level of interrater reliability on sample problems, and then were asked to rate each student's pre and post responses through a "blind" process in which raters knew neither the group to which any subject belonged nor whether it was a pre or a post measure.

Teachers other than the I.E. teachers were asked to rate all experimental students' cognitive behavior before the beginning of the experimental period and again near the end of the first project year, using a five-point scale of behaviors which reflected the major goals of I.E. (see Table 4). Because the reporting teachers were not those involved in the teacher-training group, they had no specific preconceived expectations for any changes in student behavior.

Findings and Discussion

Raven's Matrices. Since there are no suitable norms for hearing-impaired children for this test, simple frequency of correct responses was used as the best estimate of change as the result of the intervention. Tables 1 and 2 present a comparison of the I.E. experimental group and the control group at the end of the second year of intervention, on the Raven's Matrices. The gain by the I.E. group exceeds that of the control group at a statistically significant

Table 1

Raven's Progressive Matrices

(Abstract Reasoning)

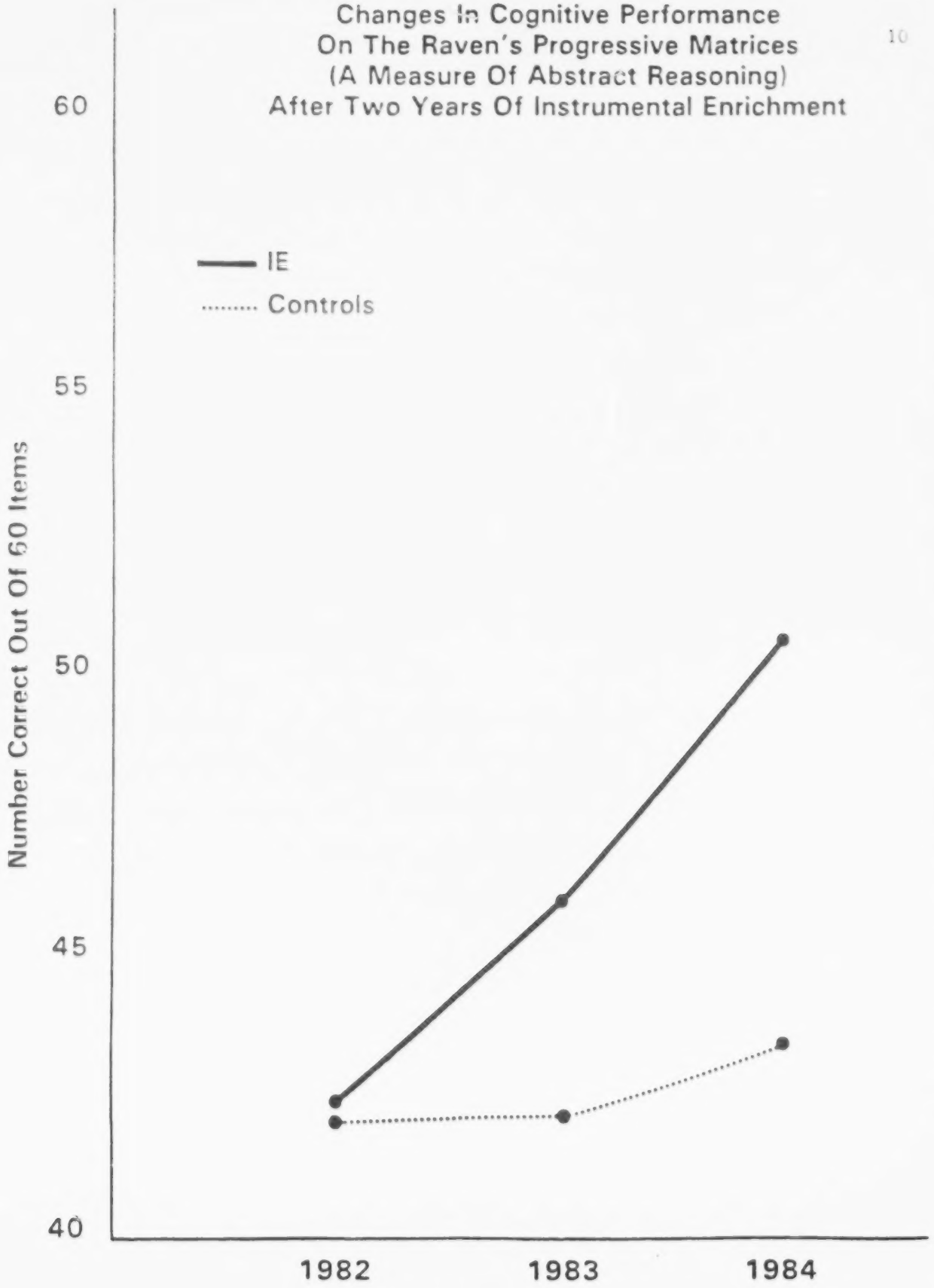
[Possible Total Score of 60]

	June 1982	June 1983	June 1984	Gain 1982-83	Gain 1983-84	Two-Year Gain	Difference
I.E. Students (N=41)	42.4	45.8	50.5	3.4	4.7	8.1	
							6.3 ($p<.01$)
Control Students (N=41)	41.7	41.9	53.5	.02	1.6	1.8	

NOTE: A statistically significant change on this test is 2 or more points (no deaf norms)

TABLE 2

Changes In Cognitive Performance
On The Raven's Progressive Matrices
(A Measure Of Abstract Reasoning)
After Two Years Of Instrumental Enrichment



level ($p < .02$). The size of the gain of the I.E. group indicates a clear trend favoring the I.E. intervention. Hypothesis 1, therefore, was accepted.

Stanford Achievement Test. The results of the November, 1982 versus the November, 1984 administrations of the Reading Comprehension subtest of the Stanford Achievement Test for Hearing-Impaired were analyzed. Comparisons were carried out using multiple analysis of variance. Results clearly favored the experimental group at the significance level of $p < .05$ (see Table 3); I.E. students improved by 15.6 scaled score points. This significant improvement in reading comprehension can be explained by the added focus through I.E. on the prerequisite skills of comparison and projection of relationships. As a result, Hypothesis 2 was accepted from a practice- oriented point of view. Table 3 compares the I.E. group to the control group on the SAT-HI subtest on math computation, indicating a significant difference ($p < .05$) favoring the I.E. group. The I.E. instructional emphases on precision, taking time to think (restraint of impulsivity), and checking one's own work would explain this important gain in the I.E. group of students. As a result, Hypothesis 3 was tentatively accepted for purposes of practical instruction.

Scores of experimental subjects on the SAT-HI math concepts subtest were contrasted with those of the control group. Again, a statistically significant difference was found ($p < .05$), indicating greater progress by I.E. students in the acquisition of math concepts by the end of the experimental period as compared to the control group.

Teacher Observation of Behavior. Table 4 displays the items used on the rating of experimental group students by teachers in courses other than those

Table 3

Results on Stanford Achievement Test, Hearing Impaired (Version 6) in Grade-Level Equivalents (G.E.)

A. READING COMPREHENSION

Group	GE 11/81	GE 11/83	Mean Gain from 11/81 to 11/83	Between-Groups Difference
Experimental (I.E.) (N=41)	4.7	6.3	1.6	
				0.8 ($p < .05$)
Control (Non-I.E.) (N=41)	4.8	5.6	0.8	

B. MATH CONCEPTS

Group	GE 11/81	GE 11/83	Mean Gain from 11/81 to 11/83	Between-Groups Difference
Experimental (I.E.) (N=41)	6.1	8.5	2.4	
				1.0 ($p < .05$)
Control (Non-I.E.) (N=41)	6.0	7.4	1.4	

C. MATH COMPUTATION

Group	GE 11/81	GE 11/83	Mean Gain from 11/81 to 11/83	Between-Groups Difference
Experimental (I.E.) (N=41)	7.5	9.4	1.9	
				0.7 ($p < .05$)
Control (Non-I.E.) (N=41)	7.3	8.5	1.2	

Table -

Teachers' Evaluations of I.E. Students' Classroom Skills and Behavior Over One Year
(1 = Low; 5 = High)

* Increase of .3 or more
** Increase of .6 or more

TYPICALLY, THIS STUDENT		September 1982	June 1983
** 1.	Corrects own mistakes spontaneously	3.0	3.6
2.	Uses dictionary spontaneously	2.5	2.5
* 3.	Takes responsibility for own supplies	4.1	4.4
** 4.	Settles down to work rapidly at beginning of class	3.3	3.9
* 5.	Makes a minimum number of errors and erasures	3.1	3.4
* 6.	Reads and follows directions spontaneously	2.8	3.2
** 7.	Takes responsibility for making up work missed	3.2	4.0
8.	Concentrates on task at hand for appropriate period of time	3.6	3.8
* 9.	Expects himself/herself to be precise, exact	3.1	3.6
**10.	Gives relevant and complete answers to questions	2.8	3.7
	ITEMS 1 THROUGH 10 = WORK HABITS AVERAGE	3.1	3.6
**11.	Willing to help others in class	3.2	3.8
**12.	Approaches new tasks and work with confidence	2.9	3.4
13.	Participates willingly in oral discussions	3.5	3.5
*14.	Volunteers to do extra work	1.8	2.3
15.	Looks for alternative ways of doing things	1.9	2.0
**16.	Works well with others in a group	3.0	4.0
*17.	Is enthusiastic about learning	3.6	3.9
**18.	Is considerate of others' feelings and listens to others	3.5	4.2
**19.	Act without impulsivity	3.2	4.0
**20.	Avoids being involved in fights and arguments	4.0	4.7
	ITEMS 11 THROUGH 20 = CLASSROOM BEHAVIOR AVERAGE	3.2	3.6

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in which that group had their I.E. experiences. Weights were assigned to each of the points on the scale with 5 being the highest possible value; responses were tallied across respondents and means were then determined for each scale item. The weighted means were then compared between pre- and post-surveys to determine changes in teacher-perceived behavior of experimental students. No tests of statistical significance of differences were possible because of the small sample size. However, differences were inspected for clear trends. Changes between pre- and post-survey items of .3 or more were considered to be noteworthy as trends because .3 represented the standard error of measurement for this analysis. Changes of this magnitude or greater were found for 16 items; comment should be made on the outstanding change (.6 or more) in 10 of these items:

Item #1. The increase in self-correction is a direct result of I.E. activities stressing the location and correction of error.

Item #4. Students in I.E. tend to move directly to expected tasks, probably because the tasks are intrinsically motivating.

Item #7. The increased sense of responsibility could derive again from the nature of the I.E. tasks as intrinsically motivating.

Item #10. The giving of relevant and complete answers is the result of the teaching methodology which stresses the discussive approach with continuous teacher demands for elaborated responses.

Item #11. The significantly increased willingness to help others in class is a behavioral by-product of I.E. because peer mediation is actively encouraged by the structure of I.E. lessons.

Item #12. The increase in confidence in tasks may be the result of the non-traditional nature of the I.E. on-paper tasks, which allows students to experience success in problem-solving where they have previously experienced some failure. Some of the tasks are non-verbal and all are content-free.

Item #16. The increase in working well with others in a group is explained similarly to the increase reported in peer assistance above (Item 11). In addition, the consistent teaching style of group discussion following completion of each day's exercises also clearly reinforces positive intra-group behavior by members of the class.

Item #18. The reported increase (.5) in consideration of others' feelings and increase in "listening" behavior is somewhat related to the explanation reported above (Item #16). However, the improvement in "listening" skills (the hearing-impaired equivalent is "visually attending closely" to others' signed responses) indicates growth in students' openness to alternative solutions to problem situations.

Item #19. The reported decrease in impulsivity (.5) is directly related to one of the major goals of I.E.: to encourage students to take time to think through a problem before embarking upon a solution. Students often remind each other about the importance of not jumping at the first solution which comes to mind.

Item #20. This reduction in involvement in arguments is at first a paradox since I.E. stresses discussion and exchange of opinion; however, these exchanges occur in a classroom tone of objectivity rather than contentiousness. Thus, I.E. students may make progress toward a more objective expression of opinions than before.

While these teacher-reported observations are admittedly subjective and perhaps questionable because no simultaneous evaluation was able to be done on control students, these data in any case provide supportive evidence for some of the effects of this program on hearing-impaired adolescents. As such, this type of data supplements the results provided elsewhere in this report. Based on these data, Hypothesis 6 was tentatively accepted.

Problem-Solving Situations. Table 5 represents the ratings for the two groups on the one of the three problems (restaurant) in which significant differences were found between groups. Following Table 5 are sample pre and post written responses from the I.E. and control groups to the restaurant problem.

The fact that differences were found on the restaurant problem and not on the other two requires interpretation. The responses to the orientation problem and the field-trip-planning problem, which showed no statistically

Table 5

Comparison of I.E. and Control Students on Written Solutions to a Posed Problem
(Analyzed by Two Objective Raters)
[5-point scale, 1=low; 5=high]

	I.E. Group	Control Group	Significance Level
GLOBAL OR OVERALL RATING			
Pre	2.3	2.8	
Post	3.2	2.4	
Gain	+0.9	-0.4	$p < .01$
A. PRACTICALITY			
Pre	2.5	2.7	
Post	3.4	2.6	
Gain	+0.9	-0.1	$p < .01$
B. COMPLETENESS OF SOLUTION			
Pre	2.1	2.5	
Post	2.7	2.4	
Gain	+0.6	-0.1	$p < .01$
C. ORGANIZATION OF SOLUTION			
Pre	2.3	2.7	
Post	3.4	2.7	
Gain	+1.1	±0.0	$p < .01$
D. EVIDENCE OF SYSTEMATIC PLANNING			
Pre	2.2	2.8	
Post	3.2	2.7	
Gain	+1.1	-0.1	$p < .01$

significant difference between groups, may both be problems which all students become better at solving as the result of the experience of being in school and working with the regular curriculum. However, the restaurant problem may have discriminated between groups because it posed a genuine real-world situation demanding systematic thought. In any case, it is seen from Table 5 and the sample responses that I.E. students were rated independently as significantly better on the post-test in: overall solution, practicality, completeness, organization, and systematization of approach to the problem. Hypothesis 5, then, can be accepted in a limited way at this time.

One additional trend, which is not displayed in the accompanying tables, is that experimental students showed a clear trend to move up in their achievement-placement level in the school when going from first to second year in I.E.

Summary and Recommendations

At the end of the second year, hearing-impaired students who have had systematic experiences in "cognitive education": (a) show consistent improvement in problem-solving; (b) significantly improve in their logical thinking as shown on the Raven's Matrices; (c) more frequently demonstrate a variety of cognitively based behaviors in the classroom, as shown by teacher observation checklists; (d) demonstrate important gains in reading comprehension; and (e) demonstrate important gains in mathematical computation and mathematical concepts.

In regard to the cognitive problems of the hearing-impaired cited earlier in the review of the literature, these data indicate that this intervention holds promise for the improvement of: spatial reasoning skills (Parasnis & Long, 1979), ability to consider two or more sources of information

simultaneously (Otten, 1980), ability to carry out analogical reasoning (Meadow, 1980), develop the concept of comparison and opposition (Furth, 1964; Meadow, 1980), and understanding of cause and effect relationships (Johnson, 1981). To the degree that memory is involved with the reading comprehension and mathematics computation subtests of the SAT-HI, it would also appear that the memory problem cited by Karchmer and Belmont (1976) is amenable to improvement. In addition, the emphasis on metacognition activities during I.E. lessons must be considered as at least one factor in the improvement of experimental students; this interpretation should corroborate the finding elsewhere (Peterson, et al., 1983) that students who can explain why they understood a cognitive task tend to have higher achievement scores.

From these results, the following recommendations emerge for future efforts in cognitive education of hearing-impaired adolescents:

1. Systematic (as opposed to incidental) cognitive intervention is important in the context of the ongoing school curriculum.

2. Adolescence is apparently not "too late" in the development of a hearing-impaired learner to make important and measurable modifications in cognitive functioning.

3. In-depth teacher training in cognitive education is an essential prerequisite to the success of any cognitive intervention program with students.

4. Future studies should investigate in depth the apparently positive perceptions of teachers who are engaged in cognitive education--just why are they so enthusiastic?

5. Still larger student samples and more complex evaluation designs are needed in order to assess in more depth the statistical effects of this intervention for hearing-impaired adolescents. Included in such studies should also be an investigation of possible aptitude-treatment interactions.

The continuing high enthusiasm of the original teachers has led to the involvement of a total of 45 teachers at the school in cognitive education for

1986-87. Thus, we see strong professional commitment to the idea that positive growth is occurring in the problem-solving skills of the students in this population. Such professional commitment and enthusiasm may be the most important indicators of all.

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